INTEGRATED ANALYSIS DEVICE FOR SIMULTANEOUSLY DETECTING EBCS AND VOCS IN HUMAN EXHALED BREATH

FIELD OF THE INVENTION

The present invention relates to an integrated analysis device for simultaneously detecting human exhaled breath condensates (EBCs) and volatile organic compounds (VOCs) in exhaled breath, and in particular, to an integrated analysis device in which a light addressable potentiometric sensor (LAPS) is employed to detect EBCs, a simultaneous sampling, separation and condensation of EBCs and VOCs from human exhaled breath can be achieved, and a VOC detection module with an combined structure is employed.

BACKGROUND OF THE INVENTION

Recently, human exhaled breath has been widely studied around the world, and these words primarily focus on the relevance of EBCs and VOCs in exhaled breath to human diseases.

To study EBCs and VOCs in exhaled breath, the first step is to collect these two study objects. With regard to a device for collecting EBCs, there are relevant studies around the world, and there already have been some commercialized instruments and devices, which principles rely on that exhaled breath is first passed through a condensation tube, and then the liquid EBCs are collected. Therein, for some devices the cost of detection is increased due to the condensation tube being disposable, and for some other devices the flexibility in application is insufficient due to their large-sized cooler.

Currently, there is no unified standard for the device for collecting VOCs in human exhaled breath, however, there already have been some relevant studies. In a VOCs gas collecting device developed by Michael Phillips, USA, exhaled breath is first blew into one end of a gas container by a disposable mouthpiece, wherein the other end of the gas container is connected to an adsorption tube, the gases in the container are drawn out by the adsorption tube through the other end of the pump, and thus the VOCs in the exhaled breath are captured by the adsorption tube. This device is comparatively automated, however, it takes into account neither the adsorption of the VOCs by the container and other connecting pieces, nor the adsorption temperature of the adsorption tube in every sampling process.

Furthermore, nowadays internationally the existing devices can only collect either EBCs or VOCs, and internationally there is a lack of device which can collect EBCs and VOCs simultaneously, and there is also no report about the studies of integrating two sets of collecting methods into one instrument and performing a subsequent analysis and detection.

To obtain EBCs, exhaled breath is introduced into a cooling system, and water vapor is condensed into liquid by means of a low temperature. EBCs contain water vapor, adenosine, hydrogen peroxide, ions, nitric oxide, prostaglandins, protein and nucleic acid, etc. which are brought out from the lung and the respiratory tract. With the features of simple to collect, non-invasive, acceptable to patients, etc., EBCs may become a new approach for finding the early diagnosis of lung cancer, screening of high-risk groups, etc. However, current common detection means are general immunological methods of which the detection speed is low, the process is complex, and the sensitivity is not high.

A surface acoustic wave (SAW) gas sensor has been widely applied in gas detection. However, since its characteristics are influenced by many environmental factors (such as gas flow, temperature, etc.) and the area of its sensitive region is relatively small so that it is difficult for chemical substances to be fully adsorbed to the sensor surface, its characteristic of high sensitivity cannot be completely achieved. If the working environmental conditions of the SAW gas sensor are not strictly controlled, the goal of rapidly detecting chemical substances with low trace concentrations in human exhaled breath cannot be achieved. A heating rod and a platinum resistor directly inserted in the traditional outlet heating piece of capillary will expand by heat after use, and get stuck in the heating piece, which makes it difficult to replace them.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an integrated analysis device for simultaneously detecting EBCs and VOCs in human exhaled breath considering the deficiencies of the internationally existing research methods and devices.

The object of the present invention is achieved by the following solution: an integrated analysis device for simultaneously detecting EBCs and VOCs in human exhaled breath comprises a module for sampling, separating and enriching a detected object, an EBCs detection module and a combined VOCs detection module; the module for sampling, separating and enriching a detected object is connected with the EBCs detection module via a syringe pump for sample injection, and the module for sampling, separating and enriching a detected object is connected with the combined VOCs detection module via a capillary separation column.

Therein, the EBCs detection module comprises an EBC inlet, an inlet for washing liquid, a first three-way valve, a composite light addressable potentiometric sensor (LAPS) sensor for heavy metal ions, a first working electrode, a light source controlled by a signal generating circuit, a reference electrode, a second three-way valve, a urea inlet, a detecting electrode, a carcinoembryonic antigen light addressable potentiometric sensor (CEA-LAPS), a second working electrode, a Cr^{3+} ion detecting cavity and a CEA detecting cavity; the EBC inlet, the inlet for washing liquid and the Cr^{3+} ion detecting cavity are connected via the first three-way valve, the urea inlet, the Cr^{3+} ion detecting cavity and the CEA detecting cavity are connected via the second three-way valve, the reference electrode is inserted into the Cr^{3+} ion detecting cavity from its top, the composite LAPS sensor for heavy metal ions and the first working electrode are fixed to the bottom of the Cr^{3+} ion detecting cavity, the first working electrode is joined with the bottom of the composite LAPS sensor for heavy metal ions, the detecting electrode is inserted into the CEA detecting cavity from its top, the CEA-LAPS and the second working electrode are fixed to the bottom of the CEA detecting cavity, and the second working electrode is joined with the bottom of the CEA-LAPS sensor. An inlet for CEA antibody-urease compound liquid and an outlet for waste liquid are disposed at the upper portion of the CEA detecting cavity. One light source controlled by a signal generating circuit is placed at a position corresponding to the composite LAPS sensor for heavy metal ions under the Cr^{3+} ion detecting cavity, and another light source controlled by a signal generating circuit is placed at a position corresponding to the CEA-LAPS sensor under the CEA detecting cavity.

Furthermore, the CEA-LAPS sensor is built by depositing a SiO_2 layer and a Si_3N_4 film in turn on a Si substrate by the chemical vapor deposition and the photolithography, and a nanolayer and a biotin layer on the surface of the Si_3N_4 film are formed by a chemical coating method.